

## **FINAL REPORT**

### **A moored system for understanding the temporal variability of prey fields of deep diving predators off Cape Hatteras and response to Gulf Stream fronts**

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## **LONG-TERM GOALS**

Fisheries acoustics are routinely used for biomass and abundance surveys and used for behavioral and ecological studies of marine organisms. Marine mammal prey surveys are typically conducted from the ocean surface during shipboard surveys using active acoustic echosounders mounted over the side or in the hull of a research ship. The range for acoustic echosounders is limited by the absorption of sound through the water, and is dependent on the frequency produced by the instrument. Typical prey surveys are therefore limited to providing data from only the upper couple hundred meters of the water column, and often cannot resolve prey targets at the depths of deep-diving predators like pilot whales, especially with the higher frequency instruments, which are needed to resolve small prey targets and useful in the frequency differencing techniques.

The mooring system will address the temporal variability of the prey field off Cape Hatteras throughout the entire depth range observed for foraging odontocetes, e.g., pilot whales, using split-beam echosounders. Furthermore, we hope be able to resolve deep sea squids in the lower half of the water column using frequency differencing in combination with single target detection of large prey targets.

## **OBJECTIVES**

- Design and construct an autonomous, deep water, long term system to sample biological and physical
- Identify seasonal changes in prey and hydrographic fields

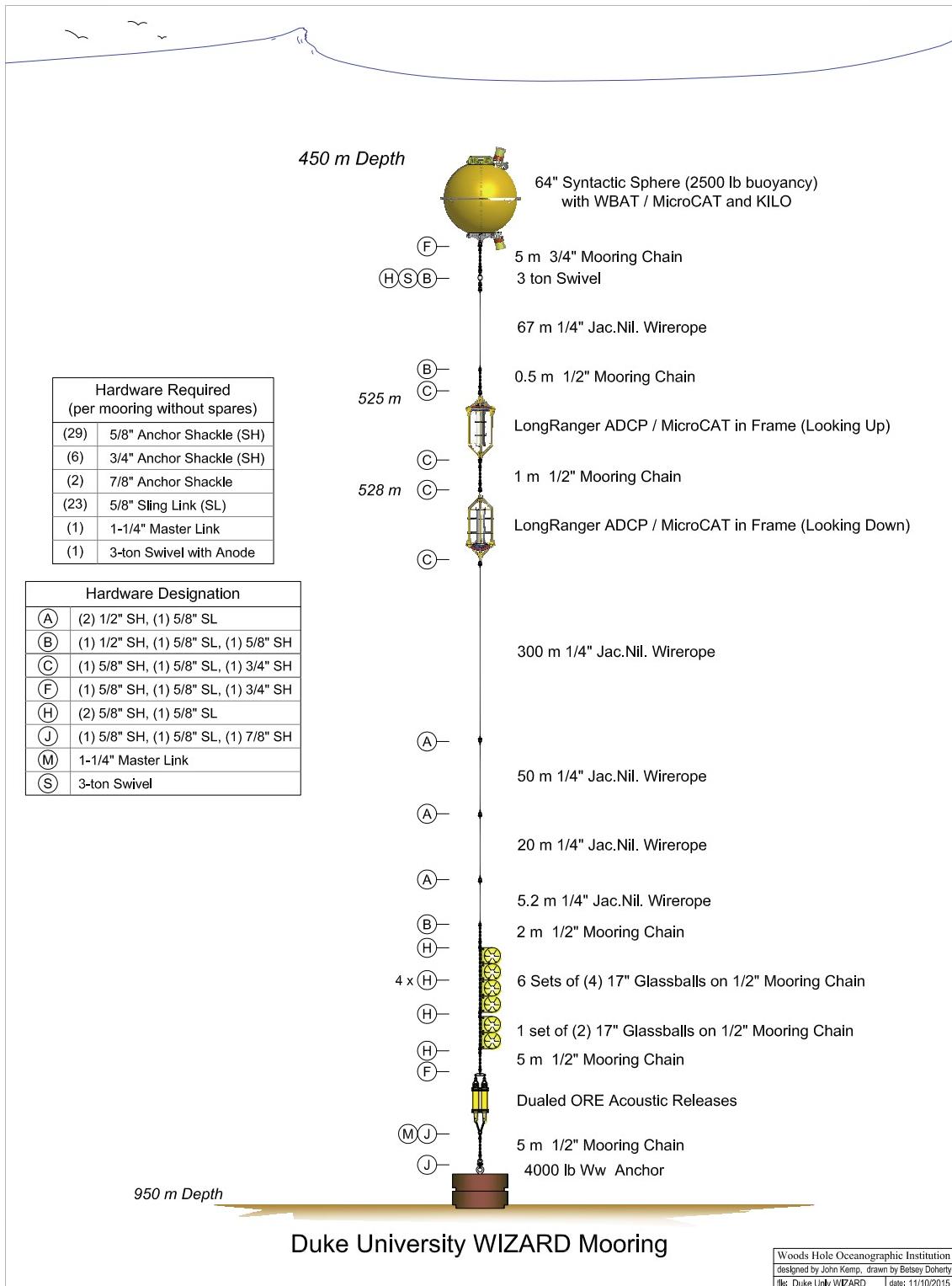
- Identify prey field response to front crossings
- Test specific hypothesis that fronts can create a barrier to prey that predators could use as an advantage in prey capture

## APPROACH

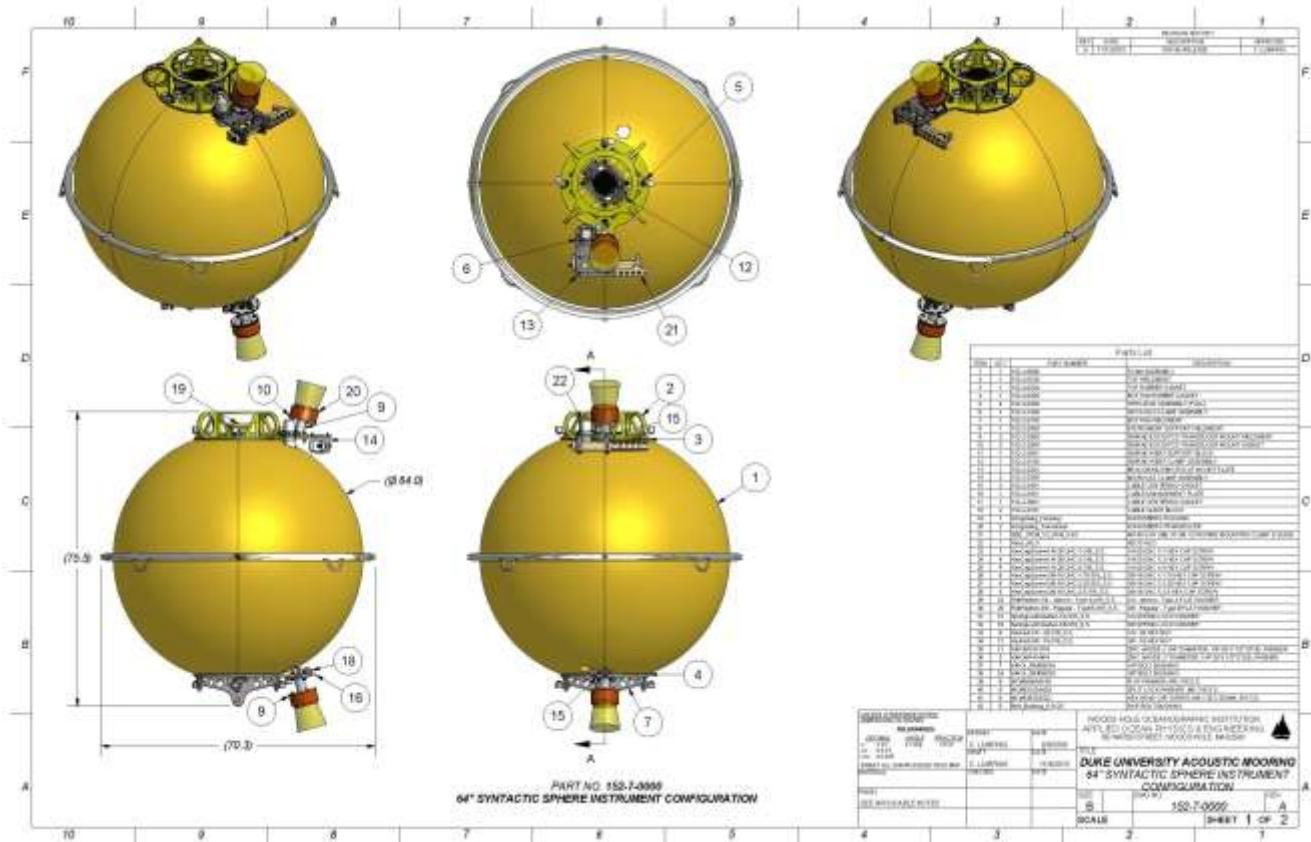
The Wideband, WoMBAT Integrated Autonomous mooring for Deep water (WIzARD, Figure 1) addresses the temporal variability of the prey field off Cape Hatteras throughout the entire water column. Relative prey density will be quantified using split-beam echosounders. The use of targeted frequencies (70 kHz and later wideband) will allow for relative frequency difference calculations that will be used to distinguish between 2 broad size classes of prey types; 1) large prey including fish and squid and 2) krill and other large zooplankton comprising the mesopelagic community. While deep diving pilot whales are likely targeting animals in the large prey category, having a second frequency to quantify the smaller size classes will help us to more accurately quantify the large prey and provide a broader ecological context to relative temporal variability of the biology for the region.

The mooring system (Figures 1-3) is designed for extended durations (servicing will be required every 10-12 months), allowing us to address the seasonality and the inter-annual variability in prey biomass and density in relation to ocean physical dynamics with low maintenance. In order to relate changes in the prey field observations to key environmental features (i.e., Gulf Stream front crossings), the mooring system will include an array of physical oceanography sensors. First, conductivity, temperature, and depth (CTD) sensors, or just conductivity, temperature sensors (CT) will be placed along the mooring periodically. We will use a combination of alternating CTD and CT sensors to get accurate depth recordings at 3 places along the mooring line to get accurate depth of each instrument. While fronts will be identified using the density measurements, specific water masses will also be identified using hydrographic characteristics (i.e., low salinity Mid Atlantic Bight water, and warm, saline Gulf stream water). Secondly, two acoustic Doppler current profilers each operating at 75 kHz (ADCP manufactured by Teledyne's RD Instruments) will measure current velocity throughout the water column. Current profiles are necessary to interpret hydrographic data by identifying time periods where upwelling may be occurring and to help understand water column dynamics by identifying the source of density intrusions. The ADCPs will be programmed to sample in long range and low power modes in order to provide data coverage throughout the entire depth range and to extend through the year-long deployments.

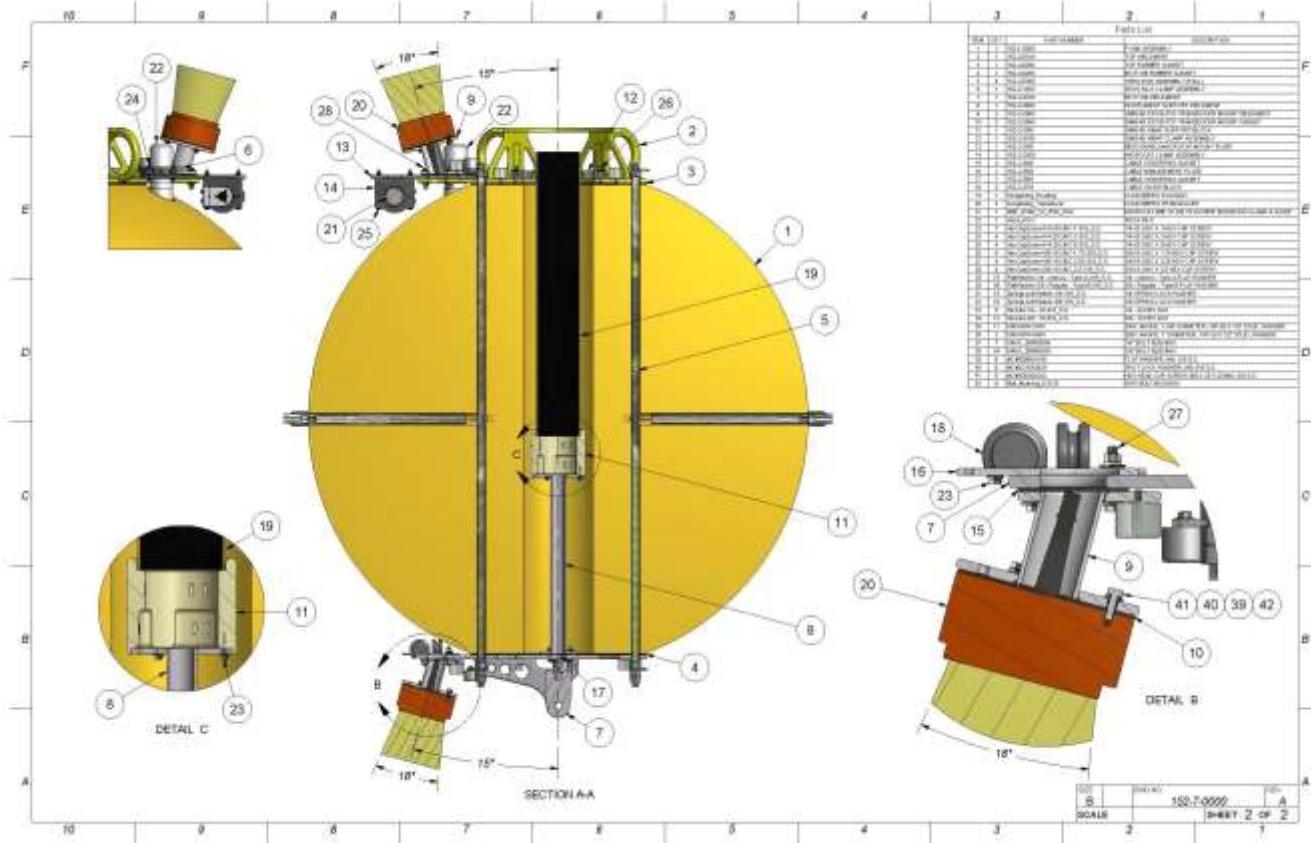
The development of this tool comes at an opportune time as Simrad, the industry leader in scientific echosounders has completed development and delivered the first Wideband Autonomous Transceiver (WoMBAT, Figure 4), and this unit along with two transducers, one looking upward the other downward (Figure 2, 3) have been incorporated into the mooring. The two transducers, both operated by the WoMBAT, are angled slightly so as to: i) avoid pinging on the mooring string (downward looking unit); and ii) to sample a continuous column of water. The echosounder system has been fully tested and calibrated.



**Figure 1.** The mooring, in its final configuration, shows the primary components of echosounders, CTDs and ADCPs. By locating the components at depths of ca. 400 m and deeper, fouling will be much less of an issue while still allowing sampling of the entire water column.



**Figure 2.** The top sphere of the mooring, to be located at approximately 450 m depth, and showing the two echosounder transducers. These transducers are canted ~15 degrees off vertical so that the downward-looking one does not continuously sample the mooring string below it, and the upward-looking one is canted similarly so that the two transducers are sampling a continuous column of water.



*Figure 3. Detail of the top sphere and WoMBAT echosounder system. The WoMBAT itself is located in the central column within the sphere, and the transducers are mounted above and below the sphere. The angled mounting for the transducers is necessitated by the need to avoid pinging on the mooring string running downwards, i.e., without the angle, the downward looking transducer would continuously sample the string. The upward looking unit is angled so that it samples the upper part of the same column of water that the downward looking one is sampling.*

## **WORK COMPLETED**

All construction is complete, the components of the mooring (WoMBAT, ADCPs, CTDs) have all been tested and calibrated. The system was transported from Woods Hole (Figure 5) to Savannah, GA where it was loaded onboard the *R/V Savannah* for the deployment cruise in mid-November, but the deployment had to be postponed due to high winds (>25 kts) and waves (10-12') at the deployment site. We will deploy the system at the next available window of ship and personnel availability.

## RESULTS

While the construction and completion of the mooring has been completed, we do not have results yet as the mooring is awaiting deployment. The testing (Figure 6) from the WoMBAT shows that the system truly is the next benchmark in quality of remotely collected echosounder data. The WBAT is a new product from Kongsberg-Simrad, and provides the industry-standard quantitative Simrad

components in an autonomous package. With this project, we have had a hand in molding this new technology as one of its original customers, and we are at the leading edge in the field.



**Figure 4.** The WoMBAT shown in the rig used to test and calibrate. One of the 70 kHz transducers is located at the bottom of the rig.

## IMPACT/APPLICATIONS

At the Duke University Marine Lab we have a very active program of work supported by and of intense interest to the DoD. This work, lead by Dr. Read, includes visual surveys and passive acoustic monitoring in three areas along the east coast of the U.S. One of these areas is precisely the location

we are proposing for this instrument, so our instrument would be co-located with the HARP and sampling in an area that is routinely covered by visual survey, both vessel and airplane based. The areas monitored by Duke's program include the Point area we have described in the current proposal as well Onslow Bay and then directly east of Jacksonville, FL and the Mayport Naval Station. Our instrument would significantly enhance the research already being conducted at the Point under the awards to Duke and Dr. Read. This research is focused on understanding the distribution and basic ecology of the marine mammals that utilize this area so that potential effects of DoD activity (e.g., Naval movements or sonar) can be monitored and better understood. The data our instrument will collect would significantly contribute to the ecological understanding of the animals and the location.

Likewise, the proposed instrument will significantly augment the research-related education currently occurring at the Duke Marine Lab. The education programs that will benefit include undergraduate, masters and PhD. At the Duke Marine Lab we have ca. 25 undergraduates in residence each semester, and these students are enriched by the research being conducted at the lab and they also have the opportunity, through independent study projects, to work directly with faculty and PhD students in analyzing data collected on various projects. At the master's level, the Nicholas School at Duke offers a professional degree in Environmental Management, and these students often focus their final projects on data collected by faculty at the Lab. Additionally, as management students they often relate the science data to some policy issue, and so the data our instrument will collect, as it helps to elucidate the ecology of the area, will be important in policy discussions. Finally, several of our PhD students have already utilized the data collected under these DoD programs, and we have current students who are already scheduled to work with the survey and acoustic data.

## **RELATED PROJECTS**

None



*Figure 5. The WIzARD mooring on the flatbed truck being transported from Woods Hole after construction and assembly were complete. The mooring was delivered to Skidaway Institute of Oceanography where it was loaded on to the R/V Savannah. The deployment cruise had to be postponed due to weather, but the system is ready to deploy.*

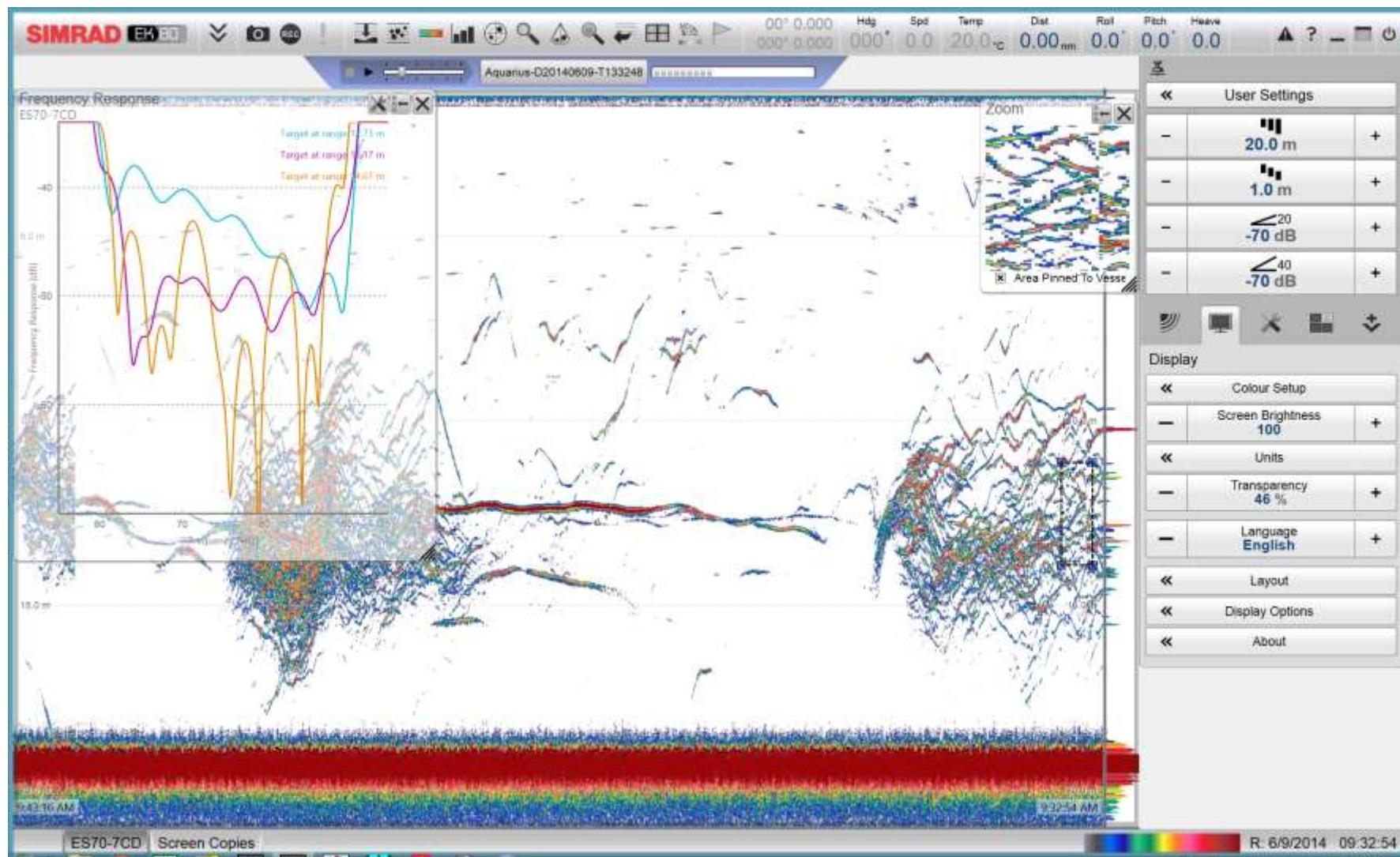


Figure 6. Data recorded by the test/prototype Simrad WBAT unit. These data, taken from the Aquarius deployment, show a school of grunts with individual targets (upper left) tracked and their reflected frequency response shown. Also, the transducer was upward looking, which is relevant as one of the mooring transducers will be similarly oriented.